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ORIGINAL RESEARCH

Effects of an intervention to reduce insecticide exposure on insecticide-related knowledge and attitude: a quasi-experimental study in Shogun orange farmers in Krabi Province, Thailand

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Abstract: An intervention to reduce insecticide exposure in Shogun orange farmers was implemented in Krabi Province, Thailand. Intervention effects on insecticide-related knowledge and attitude were evaluated in a quasi-experimental study in two farms about 20 kilometers (km) apart. The intervention was conducted at one farm; the other served as control. The study included 42 and 50 farmers at the intervention and control farms, respectively. The intervention included several components, including didactic instruction, practical demonstrations, use of a fluorescent tracer, and continuing guidance on insecticide use via a small, specially trained group within the overall intervention group. To the best of our knowledge, this was the first such intervention in Thailand. Knowledge and attitude were measured at baseline (pre-intervention), and at 2 and 5 months after the intervention (follow-up 1 and follow-up 2, respectively). Intervention effects were assessed with linear mixed models, specified to enable testing of effects at each follow-up time. The intervention was associated with substantial and statistically significant improvements in both knowledge score and attitude score ($P < 0.001$ for each score at each follow-up time). Intervention-related improvements in knowledge score and attitude score were equivalent to about 27% and 14% of baseline mean knowledge and attitude scores, respectively. Intervention-related benefits were similar at both follow-up times. Findings were similar before and after adjustment for covariates. These findings increase confidence that well-designed interventions can reduce farmers' insecticide exposure in Thailand and elsewhere. In future research, it would be desirable to address long-term intervention effects on farmers' health and quality of life.

Keywords: insecticides, pesticides, intervention, farmers, knowledge, attitude

Introduction

Exposure to insecticides through consumption of fruits is widespread. Fruits are often subjected to pre- and post-harvest treatment with insecticides, particularly organophosphates, carbamates, and pyrethroids.[1] Citrus fruit crops like mandarin oranges, Shogun oranges, lemons, and pomelo are grown in many regions of Thailand. The insect pests that commonly affect citrus crops in Thailand include 23 species in six orders – Thysanoptera, Homoptera, Hemiptera, Coleoptera, Lepidoptera, and Diptera. Specific pests vary according to the kind of citrus fruit and area of cultivation.[2] Citrus growers regularly use chemicals to control pests. Repeated usage can cause resistance, leading to increased pesticide use, and quite possibly increased health risk.

Shogun oranges (*Citrus sinensis* [L.] Osbeck) are an important product in the royally sponsored One Tumbol One Product (OTOP) project in Krabi Province. In the

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Khao-phanom District of Krabi, 80% of the plantation area was used to produce Shogun oranges. In the year 2000, the surveillance report from the province showed that people from this region were getting ill from their occupation.[3] According to the Epidemiological Surveillance Report released by the Department of Epidemiology, occupation-related illness was seen in 4,337 patients and insecticide-related poisoning was the cause in 71.68% of nationwide cases.[3] The 2001 Fiscal Year Report by the Department of Sanitation reported that there were 21 deaths due to pesticide poisoning and the morbidity ratio from pesticide poisoning was 15.43:100,000.[4] In 2001–2002, there were two patients with pesticide poisoning in Krabi Province[4] and 13 patients among Shogun orange farmers in Khao-phanom District.[5] In 2011, the report 'Healthy Farmers and Safety Consumers', from the Public Health Office in Krabi Province showed unsafe levels of serum cholinesterase;[6] farmers were screened for serum cholinesterase levels by reactive paper finger-blood test. Out of 743 Krabi farmers screened, 204 (27.46%) had unsafe cholinesterase levels.[6] These reports suggest that the farmers are at risk of both short-term and long-term health impairment due to exposure to insecticides.

In recent years, though there have been efforts to improve food safety and improve public health of both the farmers and consumers, insecticide use remains high. The health risks to the farmers (high use) and health risks to consumers (due to high residue levels in the produce) are important public health problems. To develop effective solutions for this, improvements in farmers' knowledge, attitudes, and practices regarding insecticide use are necessary.

To address these issues, we conducted a quasi-experimental study to implement and evaluate an intervention aimed at reducing insecticide exposure in Shogun orange farmers in Krabi Province. The effects of the intervention on insecticide-related knowledge and attitude are reported here. To the best of our knowledge, this was the first intervention targeted specifically at reducing insecticide exposure in Thai farmers.

Methods

Study population

This quasi-experimental study was conducted on 92 Shogun orange farmers[7] in Khao-Phanom District, Krabi Province. Two farms, about 20 km apart, were selected for the study. The intervention was conducted in one farm; the other farm served as the control area. The intervention and control groups consisted of 42 and 50 adults, respectively (see Table 1). The study was conducted from April 2012 to November 2012. All participants signed an informed consent form. The study protocol was approved by the Institutional Review Board of the College of Public Health Sciences, Chulalongkorn University, Thailand (COA No. 256/2555).

Procedures

Both farms had a single owner, and cultivation practices and pesticide usage were very similar at both. In the study area, Shogun oranges are grown, and agricultural pesticides are used throughout the year – there are no distinct cultivation cycles as in rice farming. The required sample size was calculated based on a previous study[8] to detect differences with confidence = 95% and power = 80%, using the OpenEpi program (v2). Though the sample size thus calculated was 68, we included 92 participants to accommodate missing data and possible dropouts. Data were collected by a team of eight persons, which included health officers and researchers from the district.

The data collection instrument was a standardized, interviewer-administered questionnaire adapted from the Agricultural Health Study in the US[9] (2010) and local studies.[8,10] The questionnaire queried: (1) sociodemographic characteristics – sex, age, education, smoking history, drinking alcohol, health status, work characteristics, duration of work, and types and durations of use of insecticides and other pesticides; (2) knowledge regarding insecticide as assessed by 15 close-ended questions; (3) attitude regarding insecticide use as assessed by 26 questions. For each knowledge question, respondents received one point and zero points for a correct and incorrect answer, respectively (total possible knowledge score ranged from 0–15). For each attitude question, respondents checked one choice on a 5-point Likert scale ranging from 'strongly agree' to 'strongly disagree'. The score for each attitude question ranged from 5 for best attitude to 1 for worst attitude (total possible attitude score ranged from 26–130). The knowledge questions and attitude questions are shown in the appendix. The questionnaire was validated with pilot testing for clarity and reliability on 30 Shogun farmers in Prasang District, Suratthani Province, by the first author. Pilot testing showed good reliability, with Cronbach's alpha of 0.881.

Questions on sociodemographic characteristics (independent variables) were administered at baseline, before the intervention. Questions on knowledge and attitude (dependent variables) were administered at baseline, at 2 months after the intervention (follow-up 1), and at 5 months after the intervention (follow-up 2).

Table 1 Baseline characteristics compared between the intervention group and control group: continuous independent variables

Characteristics	Intervention group (n = 42)		Control group (n = 50)		P-value*
	Mean	SD	Mean	SD	
Age (y)	40.74	11.84	41.08	12.40	0.893
Years using insecticides	6.43	5.01	4.86	4.16	0.104
Days since most recent insecticide contact	5.17	5.69	3.96	3.77	0.227

Note: *By independent t-test.
Abbreviation: SD, standard deviation.

The intervention program lasted for 4 days, and drew upon the principles of Social Cognitive Theory.[11–15] The first 2 days consisted of training in insecticide-related knowledge. The first day covered pesticide utilization and problems in Thailand, types of pesticides, classification and hazard, routes of exposure, impact of pesticides on health and environment, and pesticide-related symptoms. The second day covered information on pesticide labels, guidelines for safe use, protective behaviors, appropriate personal protective equipment (PPE), first aid for poisoning, and patient transfer to medical care. The last 2 days consisted of practical training.

Day 3 covered demonstrations using a fluorescent tracer,[16] use of a baseball cap as an example of partial but suboptimal PPE, unplugging a spray nozzle, dirty fruits and vegetables, handshake, improper removal of PPE, inappropriate practice regarding cell phones and smoking, and pesticide formulations. The fluorescent tracer is used to mark areas where pesticides get on skin and clothes. Unlike pesticides, the tracer glows under a black light, and thus shows that areas can be contaminated even though the contamination is invisible. Day 4 covered actual applications as done in normal practice, with the fluorescent tracer added to the pesticides.

The intervention also included special training of ten persons in the intervention group, whom their peers had identified as highly respected. This 'model group' was available to advise intervention group members regarding insecticide use throughout the study.

Statistical analysis

Descriptive statistics were used to describe means, frequencies, percentages, and standard deviations for sociodemographic characteristics, and for knowledge and attitude scores. Baseline differences in independent variables between the intervention and control groups were tested by the Chi-square test and independent samples t-test for dichotomous and continuous variables, respectively.

At any follow-up time, the magnitude of the intervention effect is the difference between the intervention and control

Table 2 Baseline characteristics compared between the intervention group and control group: categorical independent variables

Characteristics	Intervention group (n = 42)		Control group (n = 50)		P-value*
	n	%	n	%	
Male	22	52.4	27	54.0	0.877
Education grade 5 or higher	22	52.4	24	48.0	0.675
Smoke at present	17	40.5	21	42.0	0.882
$\geq$1 drink per day	22	52.4	31	62.0	0.352
Positive chronic disease history	9	21.4	2	4.0	0.010
Growing crops in addition to oranges	16	38.1	13	26.0	0.214
Insecticide sprayer	13	31.0	14	28.0	0.757
Spray insecticide before 8 am	13	31.0	11	22.0	0.330
Spray insecticide 8 am–12 pm	10	23.8	14	28.0	0.648
Spray insecticide after 12 pm	10	23.8	11	22.0	0.837
Been trained in insecticide application	6	14.3	6	12.0	0.746
Usually uses herbicides or rodenticides	10	23.8	11	22.0	0.837
Usually uses insecticides	36	85.7	43	86.0	0.969
Usually uses fungicides	15	35.7	16	32.0	0.707
Uses insecticides >15 times/year	27	64.3	25	50.0	0.169
Sprays insecticides $\leq$200 cc/rai†	8	19.0	10	20.0	0.909
Sprays insecticides $\geq$200 cc/rai†	15	35.7	13	26.0	0.313
Uses insecticides in powder form	24	57.1	31	62.0	0.636
Uses insecticides in liquid form	29	69.0	30	60.0	0.367
Uses chemical fertilizer	36	85.7	38	76.0	0.242
Uses mosquito coils	12	28.6	5	10.0	0.022
Uses household pesticide spray	26	61.9	16	32.0	0.004

Notes: *By Chi-square test; †1 rai = 1,600 square meters, 1 acre = 2.53 rai.

Table 3 Absolute magnitudes of unadjusted intervention effects on knowledge score and attitude score, and intervention effects as percentages of baseline mean scores, at follow-up 1 and follow-up 2

	Overall mean at baseline	Intervention effects (unadjusted)					
		Follow-up 1			Follow-up 2		
		Absolute magnitude (95% CI)	*P*-value	As % of baseline mean	Absolute magnitude (95% CI)	*P*-value	As % of baseline mean
Knowledge score	11.0	2.9 (2.2–3.6)	<0.001	26.4	2.8 (2.0–3.6)	<0.001	25.5
Attitude score	96.0	13.2 (10.7–15.7)	<0.001	13.8	15.0 (12.1–18.0)	<0.001	15.6

Abbreviation: CI, confidence interval.

groups in the change in mean score from baseline to follow-up. This is given in the expression below.

$$\text{Intervention effect} = (\text{Follow-up} - \text{Baseline})_{\text{intervention}} - (\text{Follow-up} - \text{Baseline})_{\text{control}}$$

We constructed linear mixed models to quantify and test the statistical significance of intervention effects on knowledge and attitude scores at each follow-up time. Unadjusted fixed-effects models included the main effects of intervention and each follow-up time, and an intervention–time interaction term for each follow-up time. In these models, the coefficients of the interaction terms were equal to the intervention effects, as described above at the two follow-up times. Each model included a 'repeated' statement, with time as the repeated measure, the study participant as the individual subject, and with an unstructured covariance type. In separate models, intervention effects were adjusted for personal chronic illness history, use of mosquito coils, and spraying pesticides in the home (see below for explanation of this adjustment). *P*-values of ≤ 0.05 were considered statistically significant. Intervention effects were reported as absolute magnitudes and as percentages of baseline mean scores.

The overall association between knowledge score and attitude score was evaluated with an additional mixed model with the attitude score as the dependent variable and the knowledge score as the independent variable. This model also included a 'repeated' statement for time, with an unstructured covariance type. All statistical analyses were conducted using SPSS (v16; SPSS, Inc., Chicago, IL, USA).

Results

Continuous and categorical independent variables are summarized and compared between the intervention and control groups in Tables 1 and 2, respectively. Prevalences

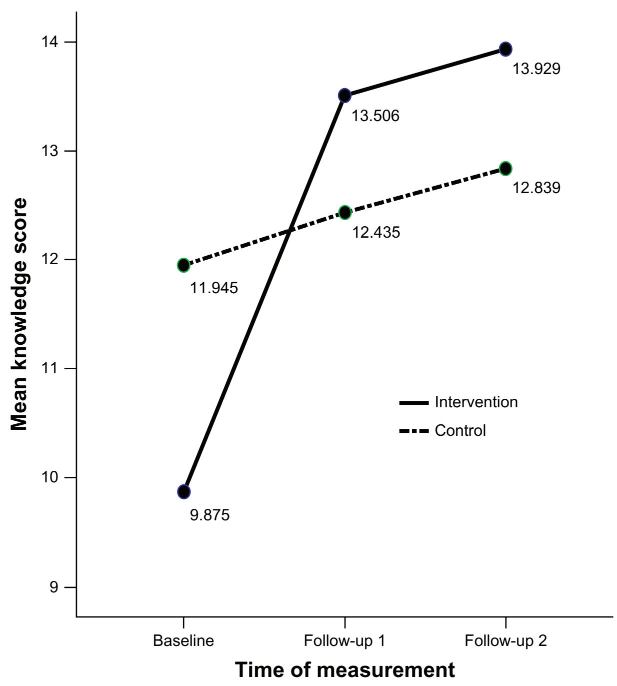

Figure 1 Adjusted mean knowledge scores in the intervention and control groups at baseline, follow-up 1, and follow-up 2. Scores were adjusted for positive chronic illness history, burning mosquito coils, and spraying pesticides in the home.

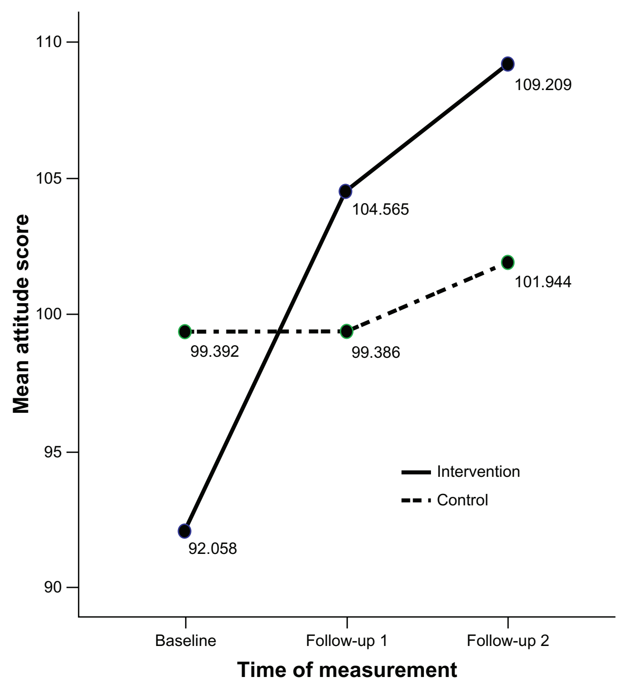

Figure 2 Adjusted mean attitude scores in the intervention and control groups at baseline, follow-up 1, and follow-up 2. Scores were adjusted for positive chronic illness history, burning mosquito coils, and spraying pesticides in the home.

of positive personal illness history, burning mosquito coils, and spraying pesticides in the home were statistically significantly higher in the intervention group than the control group (Table 2). Thus, intervention effects on knowledge and attitude scores were adjusted for these characteristics. No other baseline characteristics differed significantly between the study groups ($P \geq 0.104$), so no adjustment was made for these other characteristics.

Unadjusted intervention effects, at follow-up 1 and follow-up 2, are shown in Table 3. The intervention was associated with substantial and statistically significant improvement in both knowledge score and attitude score at both times ($P < 0.001$) for both scores for both follow-up times. For example, from baseline to follow-up 1, knowledge score increased by 2.9 points more in the intervention group than the control group. This represented an intervention-related improvement equal to 26.4% of the baseline mean knowledge score. Absolute intervention effects on attitude score were larger than on knowledge score, although proportional improvements in the former were smaller than in the latter. For each score, intervention-related benefits were similar at both follow-up times.

Adjusted mean knowledge scores in the intervention and control groups, at the three measurement times, are shown in Figure 1. Adjusted mean attitude scores are shown in Figure 2. The figures show that increases in both scores from baseline to follow-up were greater in the intervention group. This indicates a beneficial effect of the intervention on both scores. Adjusted intervention effects are shown in Table 4. Adjusted intervention effects, like unadjusted ones, were consistently beneficial and statistically significant ($P < 0.001$). A comparison of Tables 3 and 4 shows that adjustment made little difference in modeled benefits of intervention, expressed as both absolute magnitude and as a percentage of the baseline mean score.

The overall relationship between knowledge score and attitude score is shown in Table 5. There was a strong and statistically significant positive relationship between the two scores. Specifically, the modeled attitude score increased by 2.29 points for each one-point increase in knowledge score ($P < 0.001$).

Discussion

This quasi-experimental study was designed to measure and assess the effects of a novel intervention, intended to reduce insecticide exposure in Shogun orange farmers in Krabi Province, Thailand. The intervention was associated with substantial and statistically significant improvements in knowledge and attitude related to insecticide use. Our findings increase confidence that well-designed, targeted interventions can be effective in reducing farmers' exposure to insecticides in Thailand and possibly elsewhere.

As mentioned above, the intervention incorporated several components, including didactic instruction, practical demonstrations, use of a fluorescent tracer, and provision of continuing guidance regarding proper insecticide use via a specially trained model group within the overall intervention group. The study design did not enable comparative testing of the specific contributions of these components to the overall effects of the intervention. It would be desirable to address this topic in future research.

The intervention in this study was targeted specifically toward reducing insecticide exposure. Farmers in the study area and elsewhere use a wide variety of pesticides in addition to insecticides. It is quite conceivable that broader interventions, intended to reduce exposure to both insecticides and other pesticides, may be associated with larger benefits than were observed in this study. Such broader interventions should be implemented and evaluated in further research. Finally, the ultimate goal of pesticide-related agricultural interventions is to improve farmers' health and quality of life. Assessing such long-term goals was beyond the scope of the present study. Hopefully, it will be possible to conduct long-term research in the future, in which the effectiveness of interventions in achieving these goals can be assessed.

Table 4 Absolute magnitudes of adjusted* intervention effects on knowledge score and attitude score, and intervention effects as percentages of baseline mean scores, at follow-up 1 and follow-up 2

	Overall mean at baseline	Intervention effects (unadjusted)					
		Follow-up 1			Follow-up 2		
		Absolute magnitude (95% CI)	*P*-value	As % of baseline mean	Absolute magnitude (95% CI)	*P*-value	As % of baseline mean
Knowledge score	11.0	3.1 (2.4–3.9)	<0.001	28.2	3.2 (2.4–4.0)	<0.001	29.1
Attitude score	96.0	12.5 (9.8–15.3)	<0.001	13.0	14.6 (11.3–17.9)	<0.001	15.2

Note: *Adjusted for positive chronic disease history, burning mosquito coils, and spraying pesticides in the home.
Abbreviation: CI, confidence interval.

Table 5 Relationship between insecticide-related attitude score and knowledge score in study participants over all three measurement times

Independent variable	Coefficient	*t*	*P*-value	95% confidence interval	
				Lower bound	Upper bound
Intercept	73.17	25.97	<0.001	67.6	78.7
Knowledge score	2.29	10.53	<0.001	1.9	2.7

Note: Dependent variable = attitude score.

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Disclosure

The authors report no conflicts of interest in this work.

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Appendices

Appendix A – Knowledge on insecticide use in study participants (15 questions total)

Check only one choice in each question. (Correct answers are checked below. Correct answers received one point. Incorrect answers received zero points. Minimum and maximum possible total scores are 0 and 15, respectively.)

1. We can get insecticide exposure via which route?
   1. Oral
   2. Dermal
   3. Breathing
   4. All are correct √
   5. Don't know
2. We can get insecticide exposure most easily in what kind of weather?
   1. Humid
   2. Hot √
   3. Cold
   4. Fine weather
   5. Variable
3. Who has opportunity to get insecticide poisoning?
   1. Animals; birds, cows, etc
   2. Infants
   3. Farmers applying insecticides
   4. People who eat fruit, vegetables, meat
   5. All are correct √
4. Where should you keep insecticides?
   1. In a specific and safe place √
   2. In a drug cabinet
   3. In a basement
   4. In a kitchen
   5. Wherever it can be accessed conveniently
5. The more insecticide used,
   1. The more pests are killed
   2. The more insecticide the user is exposed to √
   3. The less cost agriculturists have to pay
   4. The more productive the farm
   5. The more income agriculturists earn
6. How should you treat an insecticide package after finishing?
   1. Burn
   2. Leave in the field
   3. Wash and reuse as a glass or dish
   4. Bury somewhere far away from a river and/or canal √
   5. Sell for second-hand use
7. How should you protect yourself from insecticide?
   1. Cover mouth and nose with a thin cloth
   2. Wear a face cover, a long-sleeve shirt and trousers
   3. Wear a mask, long gloves, a long-sleeve shirt and trousers √
   4. Stay upwind of the spray
   5. Just wear a mask
8. What is the right instruction for insecticide use?
   1. Neighbor's advice
   2. Directions on the label √
   3. Shopkeeper's advice
   4. Up to individual experience and skill
   5. Same technique for all brands
9. How can you tell that an insecticide is very dangerous?
   1. Strong odor
   2. Dark color
   3. Skull and crossbones symbol √
   4. No label showing certification by the Food and Drug Administration
   5. Expensive

10. What is the best and easiest way to check for insecticide left over in your body?
    1. Brain scan
    2. Blood examination √
    3. Stool examination
    4. Clothes examination
    5. Electrocardiogram test
11. What is the correct reason for choosing the insecticide(s) to use?
    1. Buy according to neighbor's advice
    2. Buy according to government agriculture official's advice √
    3. Buy according to vendor's advice
    4. Buy according to advertisement
    5. Buy according to sales representative's advice
12. Which is the correct method to mix insecticide?
    1. Pour insecticide in an amount estimated by sight
    2. Stir insecticide by hand
    3. Wear rubber gloves and stir insecticide using a stick √
    4. Pour insecticide into a container and shake well
    5. Prefer high concentration
13. Persons who have ever had insecticide poisoning will be immunized, and will not have poisoning again.
    1. Yes
    2. No √
14. Using more than one type of insecticide while applying is more risky than using only one type.
    1. Yes
    2. No √
15. Taking drugs such dimenhydrinate or paracetamol before and after mixing or applying can prevent or reduce insecticide poisoning.
    1. Yes
    2. No √

Appendix B – Attitude of participants toward insecticide use (26 questions total)

Check only one choice for each question. (Positive-direction questions were scored from 5 points for 'strongly agree' to 1 point for 'strongly disagree'. Negative-direction questions were scored from 1 point for 'strongly agree' to 5 points for 'strongly disagree'. Minimum and maximum possible total scores are 26 and 130, respectively.)

Questions	Strongly agree	Agree	Don't Know	Disagree	Strongly disagree	Direction of question
1. The more expensive, the better quality the insecticide.						Negative
2. It is necessary to use insecticides every time you grow crops.						Negative
3. An insecticide consisting of many compounds is of good quality.						Negative
4. Spraying tanks can be washed in a river/canal without any harm to other animals.						Negative
5. Insecticide will only affect insects.						Negative
6. If your health is good enough, you can resist insecticide poisoning.						Negative
7. You should stand upwind while spraying.						Positive
8. All agriculturists should have a medical check-up for residual insecticide at least once a year.						Positive
9. Smoking while spraying insecticide does not increase the amount of insecticide that enters the body.						Negative
10. You can smoke, drink water, or eat food while mixing or applying insecticides.						Negative
11. Herbal insecticide usage is complicated and useless.						Negative
12. Although you have good health, you can have insecticide poisoning after exposure to insecticide.						Positive
13. You must stop spraying immediately if it is windy.						Positive
14. While mixing or spraying insecticide just a few times or while using low dosage, it is not necessary to wear PPE.						Negative
15. After applying insecticide, changing your clothes is enough. It is not necessary to take a bath.						Negative
16. Insecticide poisoning can be prevented and reduced.						Positive
17. Prolonged contact with insecticide, even after only a few dosages is more dangerous to your health.						Positive
18. Some chemical insecticides are not harmful to your health.						Negative
19. Mixing several kinds of insecticides together reduces the time spent spraying and reduces risk.						Negative
20. It is not comfortable to work while using PPE when using insecticides.						Negative
21. Even though PPE is expensive and difficult to find, it is necessary and worthwhile.						Positive
22. Taking a bath immediately after exposure to insecticide can reduce its harmful effects.						Positive
23. Separate laundry of sweaty clothes from others is costly.						Negative
24. Farmers who have had allergies will have immunity to insecticide poisoning.						Negative
25. Mild symptoms can disappear by themselves so it is not necessary to see a doctor.						Negative
26. Insecticides can cause cancers.						Positive

Abbreviation: PPE, personal protective equipment.